PETRALOGY, OR THE KNOWLEDGE OF ROCKS AND STONES.

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(*Continued from p.* 339.)

In order to form a right conception of the *modus operandi* of nature in forming rocks and stones, it is also necessary to treat more particularly upon the process of lapidification, or petrifaction as it is commonly termed, for to this process we owe the formation of rocks which are termed *amorphous*—that is, to say, *deficient of crystalline structure*. I have previously observed that every bed of earth or clay has a tendency, under favourable circumstances, to enter into the state of rock, which circumstances are produced by climate and association; thus, in one region of the earth, from the absence of heat, moisture, or other changing causes, soils continue in their disintegrated state, for ages—so long, in fact, as they continue exposed to the like influences; but in the revolutions of time and changes of the position of the earth's surface, these loose masses become exposed to new elemental influences, and it is then cohesion or crystallization takes place, whereby the bodies or portions of bodies of which such masses are composed lose their individuality, and are no longer to be distinguished in the general mass.

"Pure earth," says Aristotle, "doth not become a stone, because of its brittle, friable nature, the prevalent dryness in it not permitting it to congulate, and so by the aqueous mixed with the terrene, stones are made." Such was the philosophy of early ages, founded upon observation of nature; it is not, however, essential that water enter into their combination to produce all the phenomena, for many varieties are produced in the total absence of water, in climates where it never rains; it is, therefore, essential that we look to other causes for lapidification and crystallization, which modern knowledge enables us to do, and by analysis to separate the elementary constituents of rocks; thus we have discovered that, while water was absolutely necessary for the generation of the bodies of which rocks are composed, the bodies thus formed, and containing the elements of water in their composition, are further perfected by the presence of heat, light, and atmospheric air, the latter being an essential component of rocks and stones. Dr. Price, in his "Mineralogia Cornubiensis," observes: "That there is a petrifying quality in the earth or its juices, is manifest to those who are conversant with mining, and consider the nature of the stones which are dug out of the ground; for they frequently meet with large solid rocks, composed of several small stones, united together, of different forms, colours, and properties, with respect to the same individual rock or stone;" which is a manifest indication that its different parts were originally loose and distinct from each other, until they were conjoined into an entire solid mass, by something of a petrifying principle which cemented them together. There are, in fact, many soils, even in this country, favourable to the generation of stones, much to the annoyance of the farmer, who, not aware of this fact, expresses his wonder at the annual crop of stones, which reappear, in despite of his continued trouble to collect them; and this lapidifying process is sometimes produced by the very means which the farmer employs to fertilize the soil; the earths applied as manures uniting with the soil, natural concrete-masses are formed, which by atmospheric influences are rapidly converting into stone. Again, when lime is thrown upon sour lands, while it tends to neutralize their acids, it also forms concreted nodulates, which speedily change their condition; and when bodies, or portions of organic bodies, are disposed in these soils, they speedily petrify, or uniting the sulphate of iron with their organic constituents, they become mineral petrifactions. The well-known property of iron to form concrete masses has led to the theory that it is almost the sole cause of the production of concrete-masses; and it is observed that iron pipes and vessels buried for a long time in the soil gradually disappear, and become the cement of inclosed or surrounding masses; boilers also attach earthy matters held in suspension by the waters, and their whole interior becomes lined with a stony concrete-mass. To the presence of this metal, also, many mineral waters owe their petrifying powers, and it is also an ingredient in artificial stones; its more comprehensive character is manifest in *siderous rocks* and stones, of which I shall speak in my next article.

The experiments of Sir John Hall, quoted triumphantly by existing geologists to prove that marble is formed under an intense degree of heat and lateral pressure, were far from being a satisfactory explanation of the *modus operandi* of nature, in forming the crystalline and amorphous rocks; a much better explanation is afforded by the concretions constantly accumulating in salt-pans, boilers of steam-engines, wooden pipes through which waters charged with mineral matters and earths are conveyed, &c. The boiling springs or fountains of Iceland may also be quoted as illustrations of the lapidifying process, the vegetable bodies on which the water falls being speedily converted into stone. The crystallizing waters are here composed of a large portion of alumine as well as silica, uniting with them potash and other compounds. At Carlsbad, in Bohemia, there are similar springs.

The hot springs of the Valley de Fournos, in the Island of St. Michael, rising through granitic and schistose rocks, precipitate vast quantities of siliceous matter, and the herbage and leaves, encrusted with silex, exhibit all the stages of petrifaction, from the soft pulpy state to the complete conversion into stone. The river Chosrun may also be noticed for the lapidifying quality of its waters; for if the root or branch of a tree fall so that a portion of it lies within the waters, the portion thus immersed becomes petrified, but the other part of it remains in its natural state. When the current is most rapid, then the transformation is most readily effected; the substance transformed always retains its natural porosity and the texture of its fibres. In Africa, several parts of America, and Asia, localities exhibit the like phenomena of lapidification.

The lapidifying waters near Marsighi, close by Tabreez in Persia, are too remarkable to escape our notice. "Here," says M. Morier, "the process of petrifaction is to be observed from the beginning to its termination. In one part the water is clear, in a second it appears thicker and stagnant, in a third quite black; and in the last stage is white like hoar-frost. Indeed a petrified pond looks like frozen water; and before the operation is quite finished, a stone slightly thrown upon it breaks the outer coating, and causes the black water underneath to exude. When the operation is complete, a stone makes no impression, and a man may walk upon it without wetting his shoes. Wherever the petrifaction has been hewn into, the curious process of the concretion is clearly seen, and shews itself like sheets of rough paper placed one over an other in accumulated layers. Such is the constant tendency of this water to become stone, that where it exudes from the ground in bubbles, the petrifaction assumes a globular shape, as if the bubbles of a spring by a stroke of magic had been arrested in their play and metamorphosed into marble.

The substance thus produced is brittle, transparent, and sometimes most richly streaked with green, red, and copper-coloured veins. It admits of being cut into immense slabs, and takes a good polish. Its use is restricted to royalty.

The island of Ascension also exhibits many curious specimens of recent breccia and conglomerate; the beaches being an amalgum of oceanic, animal, and vegetable exuviæ, sands, and waters charged with ocean slime are rapidly hardened into these products, which contain turtles' eggs, and many other curious animal remains. The limestone of Gaudalope, containing human fossil skeletons, are also singular evidences of the recent induration of earths.

Mr. Lyall, in the last edition of his "Elements of Geology," attempts to explain the process of lapidification, by assuming that strata are very generally permeated by water charged with minute portions of calcareous, siliceous, and other earths, in solution, and the above examples furnish him with arguments in favour of this opinion; but, in nature, as I have previously demonstrated, there are other and more extensive processes by which lapidification is conducted without the aid of water, and solely by the agency of long continuous atmospheric or chemical heat.

The recent attempts of Professor Göpperts, of Breslau, to imitate the lapidifying process of nature, like the attempts of Sir John Hall to imitate the crystallizing process, was an approximation to one, or perhaps more, of the numerous means by which nature effects her purposes, but cannot be quoted as the law of nature, but rather is the power of imitation by which man, in this and many other respects, is enabled to mould the material of the earth to his wants and purposes. The professor steeped a variety of animal and vegetable substances in waters holding in solution siliceous, calcareous, and metallic matters. He found that in a period of three weeks, or even days, the vegetable bodies thus immersed were mineralized to a certain extent. Thin slices of Scotch deal were immersed in a moderately strong solution of sulphate of iron. When they had been for several days thoroughly soaked in the liquid, they were dried and exposed to a red heat until the vegetable matter was burnt up and nothing remained but an oxide of iron, which was found to have taken the form of the deal so exactly, that even the dotted vessels peculiar to this family of plants were under the microscope distinctly visible.

This is art, not nature: many nodules and large aggregate bodies, it is true, silicify upon being permeated by silica, or mineral acids, or gaseous products, but then silica invariably becomes the base, the carbon of the permeated body undergoing a change, and passing, by a new combination with oxygen, into the compound form termed silica; for here, with due deference to the eminent chemists of the age, I must express my decided conviction that silica is none other than the re-combination of the elementary constituents of carbonaceous, albuminous, and gelatinous bodies, with oxygen, chlorine, or iodine, and all the phenomena of change termed petrifaction confirm this view; for how otherwise could the shells of fishes, nay fishes themselves, and other portions of animals, as well as of vegetable bodies, become, on mere exposure to atmospheric action, converted into silicates, unless a radical change took place in their elementary constituents, which, as is palpably manifest to observation, as it is confirmed by experiment, have combined with an extra dose of oxygen: it can be demonstrably shewn that they do not derive this material from the soil on which they are disposed, for the whole bed, so far down as the influences of light and heat extend, is composed of the like silicified substances, and at the lower depths the fossils have maintained their primary condition, and are very often wholly unimpaired.

So essential are locality and climate to the formation of rock, that many varieties may be considered as existing monuments of change in the position of the earth, equally as certain and convincing as the existence of vast quantities of animals and vegetables, both of the land and waters, which could only have existed and propagated their species in an unbroken line of generations, while disposed beneath the tropics. The very high degree of oxydation of many of the hill and mountain-chains of Europe is demonstrative proof that they at one period of time were subject to long and continuous intense heat, such as we now find in tropical regions. The iron of Finmark, says Von Buch, actually forms mountains, and it is remarkable how great the similarity is between this ore and the lores of Asia, both being highly oxydated. The ironstone here is everywhere with difficulty pressible, and yields an iron which is brittle when cold. It exceeds in richness the ironstone of Sweden, but, as is the case with oriental iron, requires to be mixed with other kinds of a more pliant quality; this ironstone is analogous in every respect to the ironstone of Hindostan, which is chiefly disposed in elevated plains or mountains. Again; the same remarks are equally applicable to rocks: farther, Von Buch observes of gneiss: "Nature in the higher latitudes is so accustomed to gneiss-formations, that she always returns to it; and even when mica-slate, limestone, and clay-slate, make their appearance, they merely resemble a series of movements, which have spread towards the North Pole without having their origin here." The same remarks apply to the porphyritic and jasper rocks; the causes by which they were produced have ceased in these northern lati-